Rehabilitation of two railway bridges

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The article presents case studies of rehabilitation of two railway bridges on the Bhusaval-Nagpur section of the Central Railway. While one bridge was seriously damaged due to rolling of wagons occurring due to the derailment of a goods train, the other showed serious distress due to ageing. The rehabilitation work was carried out without much disturbance to the rail traffic.

Case study No. 1

A bridge at km 555/26-36 between Shegaon and Akola stations on Bombay-Howrah trunk broad gauge route was seriously damaged due to the derailment of a goods train. Some of the wagons of the train had rolled and fallen into the river bed, thus damaging a part of the substructure.

This bridge, constructed about 80 years ago, has 15 spans of 17.475m, with steel plate girder superstructure. Abutments and piers are in masonry with the maximum pier height being 19.2 m above bed level, Figure 1.

The following main damages occurred on account of derailment

1. pier No. P6 sheared off at a height of 6 m above bed level
2. small cracks occurred in the stone masonry and bed blocks of other piers due to the movement of derailed wagons
3. a large number of cracks developed in pier No. P10.

After the detailed investigations, the following remedial measures were suggested :

1. rebuilding of pier No. P6 in concrete grade M20 with temperature reinforcement
2. repairing small cracks in all piers with cement pressure grouting
3. epoxy grouting of all bed blocks and pier No. P10 which developed a large number of cracks.

Epoxy grouting was done for a total area of 640m^2. The following procedure was adopted.

1. The area to be epoxy grouted was cleaned by wire brush removing all loose materials.
2. Holes of 7 to 10 mm diameter and 40 to 50 mm deep were drilled along the cracks at 500 mm on centres with the help of pneumatic drilling equipment.
3. Polythene pipe pieces of 8 mm diameter were fixed as grouting nipples using epoxy mortar.
4. All cracks were cut to a V-shape groove of about 10-mm deep. Loose material was removed by compressed air using air compressor of 3 to 4 m^3 per minute capacity (pressure of 10 kg/cm^2). The grooves were fully sealed using epoxy mortar atleast one day in advance.
5. The epoxy was prepared and injected into the holes by pressure injection equipment. The injection was started from the bottom most holes and done vertically upwards. When the epoxy started flowing from the adjoining holes, further injection was stopped. All other holes were kept properly plugged. Since the height of the pier was 19.2 m, bamboo scaffolding around the pier for climbing of drilling machine and epoxy grouting operators was done. Cracks pattern can be seen in Figure 1. Figure 2 shows a view of epoxy grouting work in progress for pier P10.

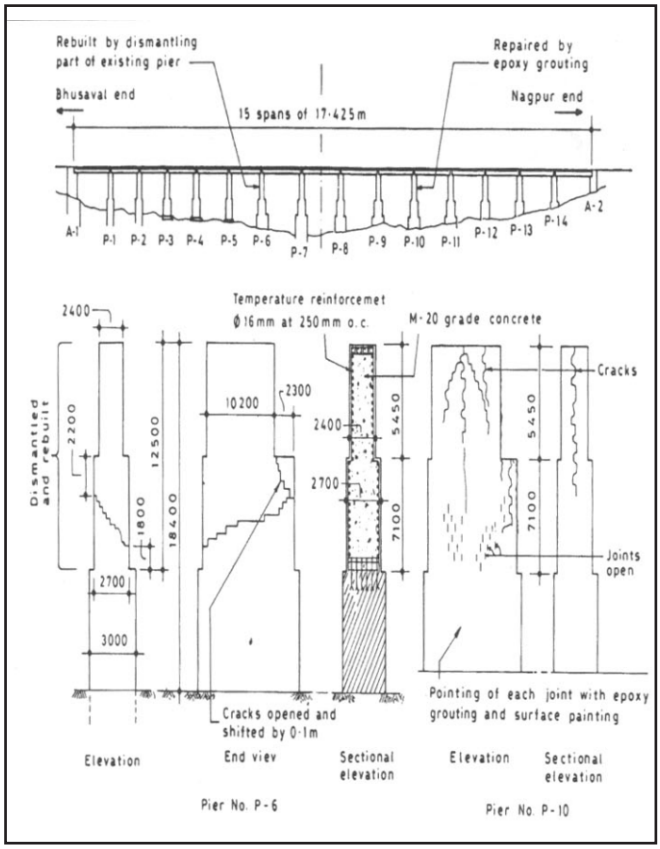

Figure 1. General elevation and cross-section of a railway bridge (Case study No. 1)

Case study No. 2

The bridge at km No. 560/16-18 on Bhusaval-Nagpur section of Bombay-Howrah broad gauge trunk route having two spans of 5.048m, showed a number of signs of distress. These included bulging of abutments due to a number of cracks going upwards, cracks in pier masonry leading to leaching of mortar from the joints and decay in some of the stones of masonry substructure due to weathering action. In view of these signs of distress, speed restriction of 50 km/hr was imposed on the bridge as a precautionary measure. At the same time, it was also decided to rebuild the entire bridge, Figure 3.

The rebuilding of the bridge was to be carried out without much disturbance to the rail traffic.

The following scheme was proposed after considering various alterations.

1. Dismantling masonry piers and abutments after providing temporary supports to the superstructure.

2. Precasting segmental box sections of suitable dimensions separately.

3. Inserting the box sections in the nullah bed.

4. Removing temporary supports and transferring superstructure load on the box.

Rebuilding procedure

Precasting work of all the reinforced concrete segments was undertaken before starting the work. In all eight segments were cast, four on the upstream and four on the downstream side of the bridge. The grade of concrete used was M20.

Excavation of the nullah bed was done in a slope of 1 in 10. After the excavation, 200-mm thick soling was provided on the bed and a 100-mm thick plain concrete (mix proportion 1:4:8) was laid over it. An assembly of four layers of wooden sleepers was then laid at a spacing of lm parallel to the track. Over each assembly of wooden sleepers, seven 44-kg rails were laid and screwed to the sleepers. Temporary girders of 16.3m span were then launched with the help of two 20-t cranes. The launching was completed in 4 hours during which the traffic was blocked.

After providing temporary girders, existing stone masonry abutments and piers were dismantled. This was done with the help of pavement breakers and compressors.

Placing RC box

An excavation of 635 mm below the bottom of RC box was done. The level of RC box was fixed precisely as the top of the box was related with the rail level. The height difference between the top of the RC box and the rail level was 900 mm and the height between the top of the box and the bottom of temporary girder was 175 mm. Thus, there was sufficient gap

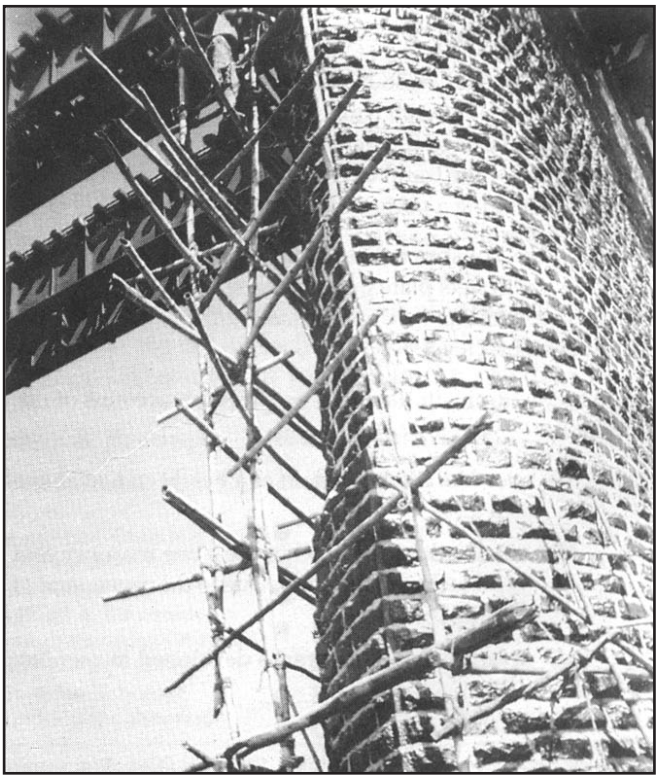

Figure 2. Epoxy grouting work in progress for pier P10

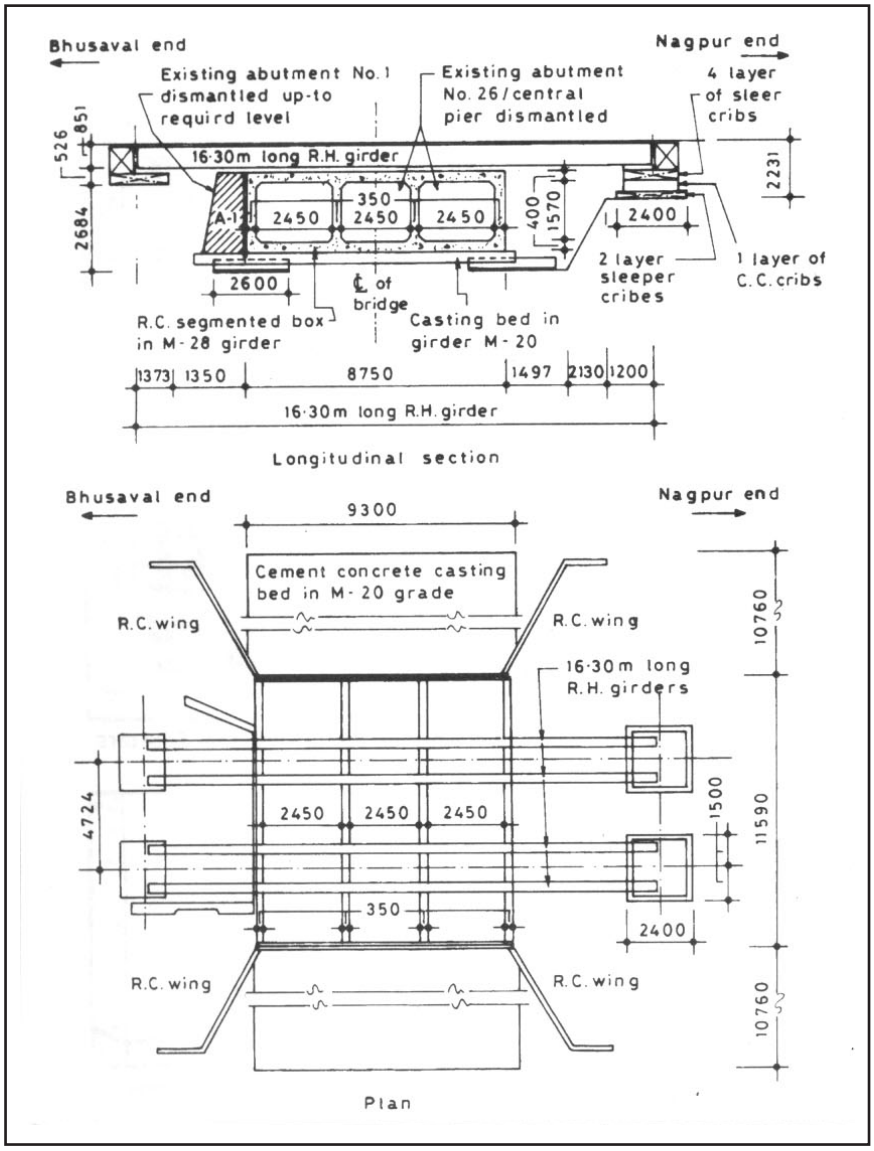

Figure 3. Temporary arrangement for rebuilding of a railway bridge (Case study No. 2)

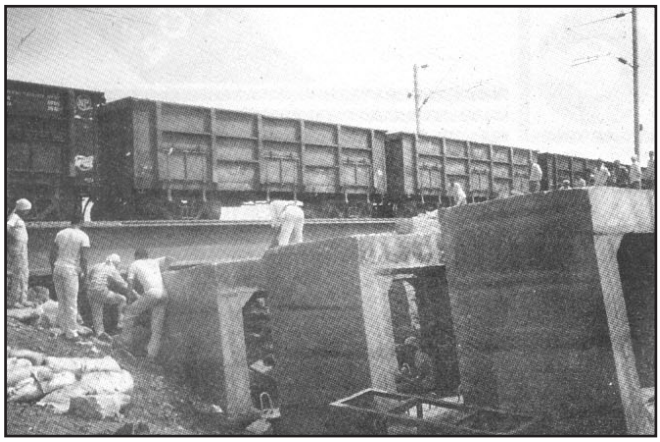

Figure 4. Precast concrete segment being pushed in the gorge of nullah while a train is moving with a restricted speed of 20 km/hr

below the temporary girder for inserting segments box. After excavation, 200-mm thick boulder layer was laid. Over it, a 150-mm thick levelling course and 260-mm thick layer of M15 concrete were laid. Four 44-kg rails were embedded in M15 concrete for holding the segments and to slide the segments in proper position and in proper alignment. Steel channels were fixed in the bottom of the slab, so that there should be minimum friction during the pushing of the segments to the proper position.

Insertion of segments

The segments were placed in proper position by sliding on the rails with the help of screw jacks. The holding of the segments was done with the help of three screw jacks, and these jacks were to be driven, at the same time to move the segment slowly and simultaneously, Figure 4. After sliding one segment by 30 to 40 cm, the next segment was slided. It was ensured that during the sliding process, other segments were duly packed and there was no movement. Sliding was done simultaneously on both the sides with three screw jacks, each with proper co-ordination. After placing of the segments in position, joints were filled with cement mortar 1:2 and cured for 7 days. Wearing coat of M10 concrete was cast with nominal reinforcement. Wings and returns were cast in M20 grade of concrete. For protection of segments, outer drop walls have been cast on both the sides and stone pitching done.

Removal of temporary girders

Removal of temporary girders was done after the sliding process was over with the help of two 20-t capacity cranes under a power and traffic block of 4 hours and the speed restriction was released from 20 to 30 km/hr and subsequently to 105 km/ lu-, that is, normal sectional speed on Bhusaval-Nagpur section of the Central Railway.

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